NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT | **NBS REPORT**
1003-20-4707 | January 29, 1953 | 2228

PROGRESS REPORT ON

WATER-VAPOR TRANSMISSION IN REFRIGERATED WAREHOUSES

October 1 to December 31, 1952

by

F. J. Powlitch, Jr.
Heating and Air Conditioning Section

for

Office of The Quartermaster General

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

The publication, reprinting, or reprod ed unless permission is obtained in writing
from the Office of the Director, Natio is not needed, however, by an agency for
which a report has been specifically that particular report for its own use.

Approved for public release by the
Director of the National Institute of
Standards and Technology (NIST)
on October 9, 2015.

Progress Report

WATER-VAPOR TRANSMISSION IN REFRIGERATED WAREHOUSES

October 1 to December 31, 1952

Construction of the apparatus for the measurement of water-vapor transmission through warehouse panels was continued.

Several nozzle shapes were investigated to determine the shape for maximum air flow through a rubber hose from the warm side heater duct to the humidifier hanging from the rotatable cantilever weighing device. A suitable nozzle was constructed and installed. (See sketch of previous Progress Report No. 1995.)

Two units of "Twindow" windows were installed in the warm side of the apparatus and in the desiccant box to facilitate reading of the dial gages on the cantilever scale.

Flexible hoses connecting the cold chamber and the desiccant box were insulated, vapor-proofed and installed. A blower was installed to circulate air from the cold box to the desiccant box. Preliminary air flow measurements were made and the heat gain to the desiccant box was estimated. Calculations indicated that the temperature rise in the desiccant box was too large so an auxiliary cooling coil was installed in the box and connected to the present refrigeration system.

A solenoid-operated hose clamp was designed, constructed and installed. The hose clamp controls the flow of air to the humidifier.

Calibrations for a new potentiometer, standard cell, watthour meter and the copper-constantan thermocouple wire were obtained. Tables of emf versus temperature in steps of 0.1 degree F for a range of -40 degrees F to 135 degrees F were calculated, based on the calibration of the wire.

The uniformity of the wire was checked by measuring the emf of three thermocouples made from samples of wire taken from the ends and the middle of a 5-pound roll. The thermocouples checked each other at steam and ice temperatures indicating good uniformity of the wire.

The results of water vapor permeance determinations on the polyethylene films used in the construction of the apparatus were received and are as follows:

1. 0.002 in. thickness - 0.23 perms*
2. 0.004 in. thickness - 0.08 perms

* Perm = one grain per square foot per hour per inch of Hg.

A meeting was held of Section personnel and a representative of the Office of The Quartermaster General. The scope, conditions of test and the type of test panels to be measured were discussed. Some preliminary designs of test panels were developed.

A visit was made to American Instrument Company, Silver Spring, Md. to examine humidity-measuring equipment and wiring similar to those on order for the apparatus. The existing devices and proposed devices for measuring humidity inside of building sections were discussed.

A short talk was given on the construction and proposed operation of the apparatus for the measurement of water vapor transmission to representatives of the Office of The Quartermaster General and the University of Minnesota.

A control board for the apparatus was designed and partly constructed. Thermocouples and reference junctions for sixty-six temperature measurements were installed in the apparatus and on the control board.

The design of the apparatus is complete and the construction phase of the apparatus is 90% complete. Some delay was experienced in the

procurement of instrumentation. At the close of the quarter all but one instrument was on hand and that instrument has been promised in a week. Completion of the construction and the start of the calibration of the apparatus is expected to begin in February.

At the request of Mr. Feilzer of the Office of The Quartermaster General detailed drawings of the rotatable cantilever weighing device were prepared and are being transmitted with this report. The deflection of the cantilever beam under load is directly proportional to the load on the beam and follows the formula

$$d = \frac{PL^3}{3EI}$$

where d = deflection, inches

P = load, pounds

L = length of beam, inches

E = modulus of elasticity (approx. 19×10^6 psi)

I = Moment of Inertia, in^4

Since the deflection is linearly proportional to the load, provided the maximum stress in the bar does not exceed the elastic limit, intermediate loads and deflections can be calculated by interpolation if the deflections under two known loads are determined. Each of the bars used for the weighing device is dimensioned so that its deflection under maximum load is about 0.08 inch. A dial gage with 0.0001 inch graduations is used to divide this deflection range into approximately 800 parts, so that loads on the bar can be measured with an accuracy of about 1/800 of the difference between the maximum and minimum loads placed on the bar. A dial gage was selected for this purpose, instead of an electrical strain gage or similar device because its deflection

indications are not subject to change with time. A suitable gage, Model B-21, was purchased from Federal Products Corporation, 1144 Eddy Street, Providence 1, R. I.

Beryllium copper was chosen for the cantilever because of its properties of high proportional elastic limit (70-80,000 psi), small hysteresis, and a comparatively straight stress-strain curve. The beryllium copper bars (BERYLCO 25) were purchased from the Beryllium Corporation, Reading, Pa., and were heat treated one hour at 660 degrees F upon the advice of Mr. J. T. Richards, Development Engineer, for the Beryllium Corporation.

To assure that the maximum stress in each bar would not exceed half of the elastic limit of the metal, to provide a safety factor of two or more, under the maximum design load, the stress was computed by means of the formula

$$S = MC/I$$

where S = Bending stress, psi

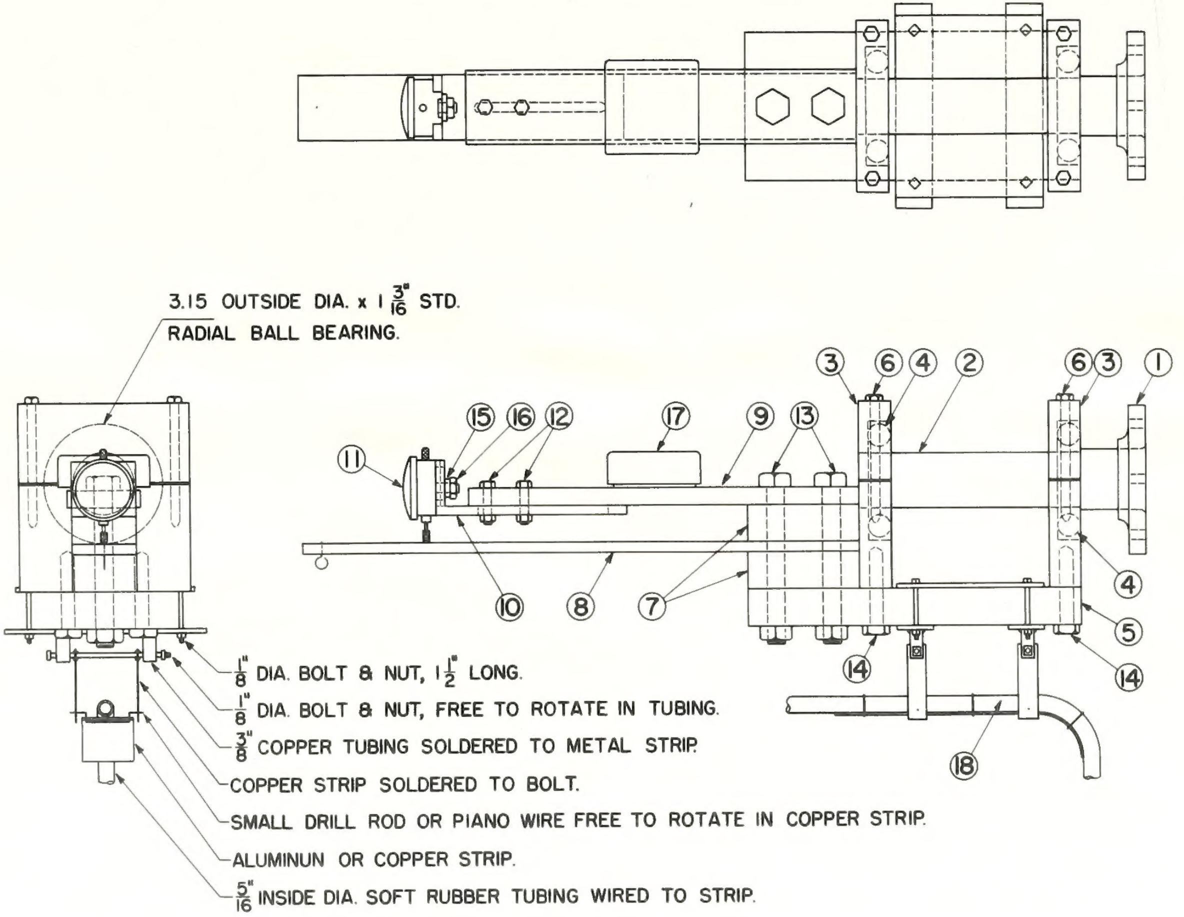
M = Bending Moment, in-lb

C = Distance from the neutral axis, inches

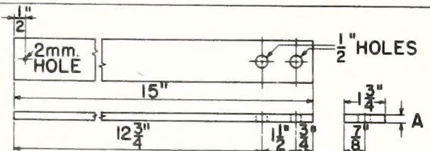
I = Moment of Inertia, in^4

The two weighing devices were assembled and the performance of two of the cantilever bars under load was investigated. It was found during experimental measurements that the load deflection curves of the assembled devices closely approximated straight lines over the working load range, but that a slight vibration of the system was necessary to assure reproducibility of dial gage readings by overcoming its frictional

resistance. A doorbell buzzer was attached to the gage-supporting arm of each of the cantilevers to overcome frictional resistance. It was found necessary to devise a pantograph arrangement to relieve tension in the hose between the cantilever load and the fixed end of the hose connecting it. In use, the load deflection characteristics of each beam will be determined in place by measurements with known loads just before and after each test.

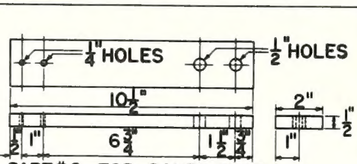

3.15 OUTSIDE DIA. x 1 3/16" STD.
RADIAL BALL BEARING.
1/8" DIA. BOLT & NUT, 1 1/2" LONG.
1/8" DIA. BOLT & NUT, FREE TO ROTATE IN TUBING.
3/8" COPPER TUBING SOLDERED TO METAL STRIP.
COPPER STRIP SOLDERED TO BOLT.
SMALL DRILL ROD OR PIANO WIRE FREE TO ROTATE IN COPPER STRIP.
ALUMINUN OR COPPER STRIP.
5/16" INSIDE DIA. SOFT RUBBER TUBING WIRED TO STRIP.
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬
⑭
⑮
⑯
⑰
⑱

SCALE: 6" = 1' – 0"

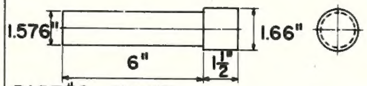


PART #8 BERYLLIUM COPPER CANTILEVER
6 REQ'D.
A { 2- .192"
2- .240"
2- .272"

SCALE : 6" = 1'-0"



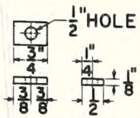
PART #9 TOP CANTILEVER
2 REQ'D. COLD ROLLED STEEL
SCALE: 6" = 1'-0"



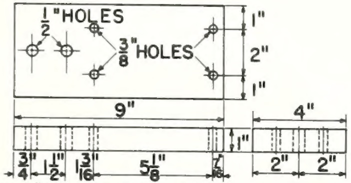
PART #2 SHAFT
1 REQ'D. COLD ROLLED STEEL BAR

1.576" dimension made to press fit with ball bearing 40 mm inside race, 80 mm outside.

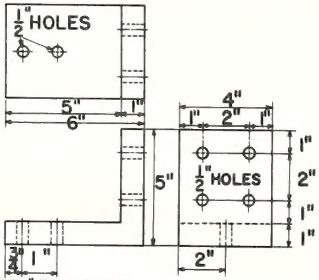
SCALE: 6" = 1'-0"



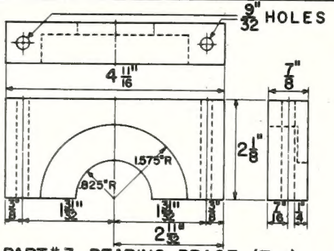
PART #15 GAGE HOLDER PLATE
2 REQ'D. COLD ROLLED STEEL
SCALE: 12" = 1'-0"



PART #5 BOTTOM PLATE
1 REQ'D. COLD ROLLED STEEL
SCALE: 6" = 1'-0"



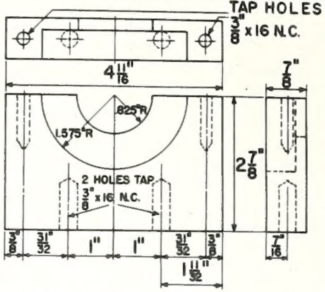
PART #5C BOTTOM PLATE
1 REQ'D. COLD ROLLED STEEL
SCALE: 6" = 1'-0"



PART #3 BEARING BRACE (Top)
2 REQ'D. COLD ROLLED STEEL

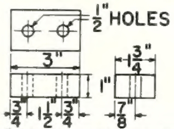
1.575" radius made to fit snugly about outer race of bearing. Top and bottom to be started as one piece. Machine 1.575" circle and tap drill 2 holes for 1/4" tap. Part, then cut into component parts and tap holes.

SCALE: 12" = 1'-0"

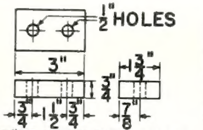


PART #3 BEARING BRACE (Bottom)
2 REQ'D. COLD ROLLED STEEL

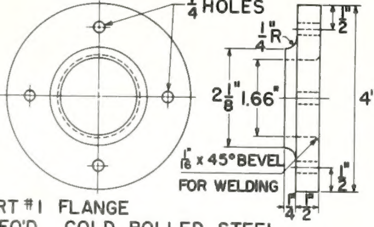
SCALE: 12" = 1'-0"



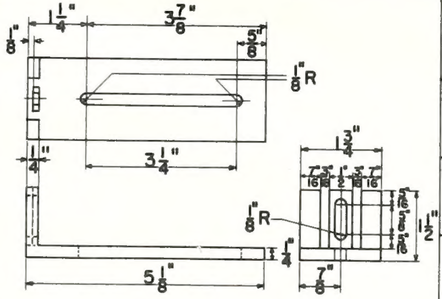
PART #7 CANTILEVER SPACERS
3 REQ'D. COLD ROLLED STEEL
SCALE: 6" = 1'-0"



PART #7C CANTILEVER SPACERS
1 REQ'D. COLD ROLLED STEEL
SCALE: 6" = 1'-0"



PART #1 FLANGE
1 REQ'D. COLD ROLLED STEEL
SCALE: 12" = 1'-0"



PART #10 GAGE HOLDER
2 REQ'D. COLD ROLLED STEEL

SCALE: 12" = 1'-0"

PART #4 BALL BEARING 2 REQ'D. N.B.S. STOCK 37-P-332 S.K.F. BEARING #6208 40 mm inside-80 mm outside-.707" thick.	PART #14 BOTTOM PLATE BOLT 4 REQ'D. 1 1/2" LONG-3/8" x 16 N.C. ALLEN HEAD
PART #6 BEARING BRACE BOLT 4 REQ'D. 3" LONG 1/4" x 20 N.C. ALLEN HEAD	PART #16 GAGE HOLDER NUT 2 REQ'D. 9/16" LONG-1/4" x 20 N.C. NUT
PART #11 DIAL GAGE 2 REQ'D. FEDERAL DIAL GAGE, MODEL B-21, .0001" Fully jeweled, revolution counter.	PART #17 ELECTRIC DOORBELL BUZZER 2 REQ'D.
PART #12 TOP CANTILEVER NUT & BOLT 4 REQ'D. 1" LONG 1/4" x 20 N.C. ALLEN HEAD 1/4" x 20 N.C. ALLEN NUT	PART #18 PANTOGRAPH 1 REQ'D.
PART #13 THROUGH NUT & BOLT 4 REQ'D. 5" LONG 1/2" x 13 N.C. ALLEN HEAD 1/2" x 13 N.C. ALLEN NUT	